APPLICATION NO. 10/772,597

INVENTION: Decisioning rules for turbo and convolutional decoding

INVENTORS: Urbain A. von der Embse

Currently amended CLAIMS

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CLAIMS

WHAT IS CLAIMED IS:

Claim **1.** (currently amended) A means for the new turbo decoding a-posteriori probability p(s,s'|y) in equations **(13)** of the invention disclosure of the decoder trellis states s',s for the received codeword k-1,k conditioned on the received symbol set y = {y(1),y(2),. . .,y(k-1),y(k),. . .,y(N)} for defining the maximum a-posteriori probability MAP in turbo decoding and which comprises:

using a new statistical definition of the MAP logarithm likelihood ratio L(d(k)|y) in equations **(18)**

$$L(d(k))|y) = \ln[\ \Sigma_{(s,s'|d(k)=+1)}\ p(s,s'|y)] - \ln[\ \Sigma_{(s,s'|d(k)=-1)}\ p(s,s'|y)\ ]$$

equal to the natural logarithm of the ratio of the a-posteriori probability p(s,s'|y) summed over all state transitions s'→s corresponding to the transmitted data d(k)=1 to the p(s,s'|y) summed over all state transitions s'→s corresponding to the transmitted data d(k)=0,

using a factorization of the a-posteriori p(s,s'|y) into the product of the a-posteriori probabilities p(s'|y(j<k)), p(s|s',y(k)), p(s|y(j>k))

$$p(s,s'|y)=p(s|s',y(k))p(s|y(j>k))p(s'|y(j<k)),$$

using a turbo decoding forward recursion equation for evaluating said a-posteriori probability $p(s'|y(j<k))$ using said $p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis

$$p(s|y(j<k),y(k)) = \Sigma_{\text{all } s'}\ p(s|s',y(k))\ p(s'|y(j<k))$$

transition path $s' \rightarrow s$ to the new state s at k from the previous state s' at k-1 and given the observed symbol y(k) to update these recursions for the assumed value of d(k) equivalent to the transmitted symbol x(k) which is the modulated symbol corresponding to d(k),

using a turbo decoding backward recursion equation for evaluating said a-posterior probability $p(s|y(j>k))$ using said $p(s'|s,y(k))$ as the state transition a-posteriori

$$p(s'|y(j>k-1) = \Sigma_{\text{all } s}\ p(s|y(j>k))p(s'|s,y(k))$$

probability of the trellis transition path $s \rightarrow s'$ to the new state s' at k-1 from the previous state s at k and given said observed symbol y(k) to update these recursions for said assumed value of d(k) equivalent to said transmitted symbol x(k) which is the modulated symbol corresponding to said d(k) and where said $p(s'|s,y(k))=p(s|s',y(k))$,

evaluating the natural logarithm of the state transition a-posteriori probability $p(s|s',y(k))= p(s'|s,y(k))$ as a function which is linear in the received symbol y(k)

$$\ln[p(s|s',y(k)) = \mathrm{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k))$$

and wherein $\underline{p}$ is the natural logarithm ln of p, x^* is the compolex conjugate of x, and ln[o] is the natural logarithm of [o],

evaluating said natural logarithm of said state transition a-

posteriori probability $p(s'|s,y(k))=p(s|s',y(k))$ equal to the new decisioning metric DX in equations **(11),(16)**.

$$\ln[p(s|s',y(k))] = \ln[p(s'|s,y(k))]$$
$$= \mathrm{Re}[y(k)x^*(k)]/\sigma^2+|x(k)|^2/2\sigma^2+ \underline{p}(d(k)$$
$$= DX$$

and which is linear in said received symbol y(k),

said new state transition probabilities in said MAP equations use said DX linear in y(k) in place of the current use of the maximum likelihood decisioning metric DM

$$DM = [\ -|y(k)\ -\ x(k)|^2/2\sigma^2\ ],$$

which is a quadratic function of y(k),

said MAP turbo decoding algorithms realizes some of the performance improvements demonstrated in FIG. **5,6** using said DX and,

said new a-posteriori mathematical framework enables said MAP turbo decoding algorithms to be restructured and to determine the intrinsic information as a function of said DX linear in said y(k).

Claim **2**. (currently amended)_ Wherein in claim **1** a means for said new convolutional decoding in said MAP a-posteriori probability p(s,s'|y) and which comprises:

using a new maximum a-posteriori principle which maximizes the a-posteriori probability p(x|y) of the transmitted symbol x given the received symbol y to replace the current maximum likelihood principle which maximizes the likelihood probability p(y|x) of y given x for deriving the forward and the backward recursive equations to implement convolutional decoding,

using said factorization of said a-posteriori $p(s,s'|y)$ into the product of said a-posteriori probabilities $p(s'|y(j<k))$, $p(s|s',y(k))$, $p(s|y(j>k))$ to identify the convolutional decoding forward state metric $a_{k-1}(s')$, backward state metric $b_k(s)$, and state transition metric $p_k(s|s')$ as the a-posteriori probability factors

$$
\begin{aligned}
p_k(s|s') &= p(s|s',y(k)) \\
b_k(s) &= p(s|y(j>k)) \\
a_{k-1}(s') &= p(s'|y(j<k)),
\end{aligned}
$$

using a convolutional decoding forward recursion equation for evaluating said a-posteriori probability $a_k(s)=p(s|y(j<k),y(k))$ using said $p_k(s|s')=p(s|s',y(k))$ as said state transition probability of the trellis transition path $s'\rightarrow s$ to the new state s at k from the previous state s' at k-1,

using a convolutional decoding backward recursion equation for evaluating said a-posteriori probability $b_k(s)=p(s|y(j>k))$ using said $p_k(s'|s)=p(s'|s,y(k))$ as said state transition probability of the trellis transition path $s\rightarrow s'$ to the new state s' at k-1 from the previous state s at k,

evaluating the natural logarithm of said state transition a-posteriori probabilities $\ln[p_k(s'|s)]=\ln[p(s'|s,y(k))]=\ln[p(s|s',y(k))]=\ln[p_k(s|s')]$ equal to said DX and,

said convolutional decoding algorithms realize some of the performance improvements demonstrated in FIG. **5,6** using said DX.

Claim **3**. (currently amended) Wherein in claim **1** A means for the new convolutional decoding recursive equations which

calculate said MAP a-posteriori probability p(s,s'|y) and which comprises:

said forward recursion equation for evaluating said natural log, $\underline{a}_k$, of a_k using said $\underline{p}_k=\ln[p(s|s',y(k))]$ as the natural logarithm said state transition a-posteriori probability of the trellis transition path s'→s to the new state s at k from the previous state s' at k-1 and is

$$\underline{a}_k(s) = \max_{s'} [\underline{a}_{k-1}(s') + \underline{p}_k(s|s')]$$
$$= \max_{s'} [\underline{a}_{k-1}(s') + DX(s|s')]$$
$$= \max_{s'} [\underline{a}_{k-1}(s') + \mathrm{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k))]$$

wherein said $DX(s|s')=\underline{p}_k(s|s')]=\underline{p}_k(s'|s)=DX(s'|s)=DX$ is said new decisioning metric,

said backward recursion equation for evaluating said $\underline{b}_k$ using said $\underline{p}_k=\ln[p(s'|s,y(k))]=\ln[p(s|s',y(k))]$ as the natural logarithm of said state transition a-posteriori probability of the trellis transition path s→s' to the new state s' at k-1 and is

$$\underline{b}_{k-1}(s') = \max_{s} [\underline{b}_k(s) + DX(s'|s)] \text{ and,}$$

said decoding algorithms realize some of the performance improvements demonstrated in FIG. **5,6** using said DX.

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CROSS-REFERENCE TO RELATED APPLICATIONS

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